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Technical Efficiency of Dairy Production in New England

Co-op Members Versus Nonmembers

Abstract

Technical Efficiency of Dairy Production in New England

Co-op Members Versus Nonmembers

Tsoung - Chao Lee, Boris E. Bravo - Ureta, Department of Agricultural Economics and Rural Sociology University of Connecticut; K. Charles Ling, Cooperative Marketing and Purchasing Division, Agricultural Cooperative Service, U.S. Department of Agriculture.

The technical efficiency in milk production of dairy farmers who were cooperative members was compared with that of dairy farmers who were not cooperative members. No statistically significant difference was found between the two groups. However, differences among farmers belonging to different dairy cooperatives were significant. In addition, socioeconomic characteristics such as operator's education; years of dairy experience; herd type; location of the farm; type of milking system; and per cow inputs of concentrate feed, forage, and labor were significant factors in explaining differences in the technical efficiency of dairy farmers.

Key words: Cooperative, milk, efficiency, average efficiency production function

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Preface

Advances in technology such as recombinant-DNA bovine growth hormone and other biotechnologies on the horizon will induce major increases in milk production. The impact on dairy farms will vary depending on how quickly farmers adopt the new technology. In turn, structural changes of the dairy industry might be unavoidable. Will dairy cooperatives be adversely affected as a result? One way to find out is to compare dairy cooperative members and nonmembers with respect to their technical efficiency of milk production. If no significant difference in technical efficiency is found, it might be appropriate to say that the technical efficiency in milk production of the two groups of dairy farmers is at about the same level. Presumably, future technological progress could be expected to be neutral in its impact on dairy cooperative members vis-a-vis nonmembers.

The specific objectives of the study were:

- To evaluate resource productivity and to determine the difference in technical efficiency of dairy cooperative members and nonmembers.
- To identify socioeconomic characteristics that explain farmer membership in dairy cooperatives and technical efficiency differentials among dairy farmers.

The data used in this study were a combination of Dairy Herd Improvement Association (DHIA) records with data from a separate study of the socioeconomic characteristics of a sample of dairy farmers in New England (See reference No. 1.) The methodology employed to measure technical efficiency requires cross-sectional and time series data for individual farms. For this reason, DHIA data for the years 1982, 1983, and 1984 were merged and farms for which data were not available in all 3 years were excluded. Data on the remaining farms, when merged with the survey data mentioned earlier, yielded a sample size of 418 observations; 333 farmers were cooperative members and the remaining were 85 nonmembers. There were 11 dairy cooperatives operating in New England.

DHIA records provided the data for estimating an average efficiency production function, which in turn served as the basis for measuring technical efficiency. The survey data contained information on herd size, barn and milking facilities, operators' participation in Extension Service programs, as well as operators' views on Extension's contribution to their operation. It also contained information on operators' membership in dairy cooperatives, and their views on why it was helpful to be members of a dairy cooperative.

The procedures followed in this study were—

- To estimate the average efficiency production function.
- To evaluate the technical efficiency of individual farmer in relation to the average efficiency production function.
- To merge the efficiency measures with DHIA and survey data.
- To cross-tabulate the efficiency measures by cooperatives and by other dairy farm characteristics.
- To test the existence of a relationship between cooperative membership and technical efficiency.

Acknowledgment

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Contents

Highlights

Are dairy farmers who belong to dairy cooperatives as efficient in milk production as farmers who are not members? Traditional measures of efficiency would compare productivity per unit of inputs, such as pounds of milk produced per pound of concentrate feed, or per work-hour, and similar items. These partial measures would not be adequate in making a true estimate of a dairy farmer's efficiency in milk production. Even the broadest measure commonly used - milk production per cow - can accurately predict only 74 percent of the time the technical efficiency of a dairy farmer as defined in this report.

This study has resulted in the development of a new method of measuring technical efficiency by employing what is called an average efficiency production function. For the theoretical and methodological part of the study, see reference No. 7.

This report summarizes the findings resulting from the application of the methodology to a sample of New England dairy farmers:

- No significant difference exists in the technical efficiency of cooperative members versus that of nonmembers. The input and output characteristics of the two groups are generally the same.
- Differences in technical efficiency exist among members of different groups of cooperatives.
- Differences in technical efficiency exist among farmers with different breeds of cows. The efficiency of farmers with Holstein milk cows is about 12 percent higher than that of farmers with other breeds.
- Differences in technical efficiency exist among farmers using different milking systems. No significant differences in technical efficiency exist among farmers with different barn types.
- Milk output per cow for nonmembers is higher than that for members partly because of the higher percentage of Holstein herds, owned by nonmembers, 91 versus 83 percent.
- A 1-percent increase in the use of concentrate feed increased milk production by 0.23 percent, while production increased by 0.12 percent per 1-percent increase in forage use.
- Socioeconomic characteristics of cooperative members and nonmembers are not significantly different. Cooperative membership is not explained by age of farm operator, years of education of operator, years of dairy farm experience, number of cows owned, technical efficiency, and extension participation.
- Differences in technical efficiency among dairy farmers can be partially explained by operator's education, years of dairy experience, herd type owned, farm location, milking system used, membership in a particular cooperative, forage and labor input per cow.

TECHNICAL EFFICIENCY OF DAIRY PRODUCTION IN NEW ENGLAND

Co-op Members Versus Nonmembers

Tsoung-Chao Lee, Boris E. Bravo-Ureta,
professor and assistant professor, respectively, of
Agricultural Economics, University of Connecticut; and
K. Charles Ling, agricultural economist, Agricultural
Cooperative Service, U.S. Department of Agriculture

Cooperatives play an important role in the U. S. food system, especially in the dairy subsector (*6*)[1]. Total dairy cooperative membership reached 164,317 in 1983 (*9*), while 77 percent of total milk volume sold by farmers was marketed by cooperatives in 1980 (*8*). In conjunction with the growing role of dairy cooperatives in recent decades, the structure of agriculture in general, and of dairy farms in particular, has changed rapidly toward fewer and larger production units.

Technological progress in dairy production has led to a continuous increase in milk production (*10*). Further, the forthcoming introduction of biotechnologies will bring about marked increases in milk production per cow and additional structural changes in the dairy industry.

The speed with which individual farmers can adopt the new technology and their ability to operate efficiently will be major factors in determining which producers will survive.

In view of past structural changes, forthcoming technological innovations, and the growing role of agricultural cooperatives, it is important to understand the role played by cooperative membership on the performance of individual farmers. Cooperatives have sought to equalize bargaining power at input and product pricing points through the pooling of input purchases and output sales of many individual farmers. In addition, some cooperatives offer their members a variety of services and information on new practices and technical innovations. The ultimate goals of farmer-owned cooperatives have been to enhance farm income, increase price stability, and provide reliable input and output markets (*2*). The question is how well dairy farmers that are members of dairy cooperatives perform compared with farmers who are not members.

An average efficiency production function model was used to evaluate productivity and determine the difference in technical efficiency of dairy cooperative members and nonmembers. The method requires use of cross-section and time-series data. After the average efficiency production function was estimated, technical efficiency for individual farms was calculated relative to the average of the sample farms.[2]

The technical efficiency measure for each farm was merged with the DHIA and survey data. Several cross-tabulations that embraced various farm characteristics - including cooperative membership - were made. In addition, the causal relationship between cooperative membership and technical efficiency was tested by expressing membership as a function of technical efficiency and other variables. Alternatively, technical efficiency was expressed as a function of membership and other explanatory variables.

[1]Italized numbers in parentheses refer to the references at the end of this report.

[2]For a detailed explanation of the methodology, see (*7*), (*3*), and (*4*).

Table 1 shows that all coefficients for the average efficiency production function were estimated at 99 percent confidence level. The coefficient for cow breed at 1.1170 indicates that Holstein herds were almost 12 percent more productive than other herds. The other coefficients can be interpreted as partial elasticities of production. The highest partial elasticity of production is 0.6177 for number of cows. It means that a 1-percent increase in number of cows results in 0.6 percent increase in milk production. The lowest partial elasticity was 0.0826 for labor. The concentrate feed and forage elasticities were 0.2257 and 0.1237, respectively. The function coefficient is 1.0497, suggesting that returns to scale of operations are nearly constant. A 1-percent increase in all inputs would lead to about a 1-percent increase in milk output. The correlation between observed milk output and the volume forecast by using the estimated production function is 0.99, suggesting that the estimated production function fits the data very well.

The average efficiency production function provides a basis for calculating the technical efficiency of different groups of dairy farmers. Table 2 shows the frequency distribution of technical efficiency of cooperative members, nonmembers, and all farms in the sample. The average technical efficiency for cooperative members and nonmembers is almost identical at 1.0010 and 1.0084, respectively.

To evaluate technical efficiency of members of individual cooperatives, the sample is grouped into 11 separate cooperatives as shown in table 3. To serve as a point of reference, average milk per cow for each group is also calculated.[3]

Note that high output per cow does not necessarily mean high efficiency. In table 1, it was shown that the correlation between efficiency and milk output per cow was 0.7384. It means that high efficiency is associated with high output per cow about 74 percent of the time.

The farmers in the sample that are members of cooperative 9 performed the best in terms of both milk output per cow and overall technical efficiency. Members of cooperatives 6, 7, and 9 did better than average in terms of technical efficiency. Farmers that were members of cooperatives 1 and 11 had a level of technical efficiency at 0.9985 and 1.0068 and were very close to average, while members of the remaining cooperatives performed below average. However, the differences in performance are not statistically significant.

Measures of technical efficiency in milk production were

[3]In all cases, milk production was adjusted to a 3.5-percent butterfat basis by using a formula similar to that presented in (5).

Table 1—Estimates of an average efficientcy production function based on a sample of New England dairy farms, 1982-1984

Variable	Estimated coefficient	Level of significance
Intercept	106.3445	**
Breed (Holstein)	1.1170	**
Cows (Number)	0.6177	**
Concentrate feed (tons)	0.2257	**
Labor (man equivalent)	0.0826	**
Forage (tons)	0.1237	**
Function coefficient	1.0497	
Number of farms		418
Simple correlation		
between dependent variable and its forecast		.9899
between efficiency and milk output per cow		.7384

** With a 99 percent level of confidence, the coefficient estimate is significantly different from zero.

Table 2—Distribution of a sample of New England dairy farms based on technical efficiency, 1982-1984

Technical efficiency interval	Number of farms			Percent total
	Members	Non-members	Total	
.65 - 75	1	1	2	0.48
.75 - 85	24	5	29	6.94
.85 - 95	78	14	92	22.01
.95 - 1.05	127	34	161	38.52
1.05 - 1.15	76	24	100	23.92
1.15 - 1.25	26	7	30	7.18
1.25 - 1.35	4	0	4	0.95
Total	333	85	418	100
Efficiency measure				
Average[1]	1.0010	1.0084	1.0025	

[1]The averages for members and nonmembers are not significantly different.

classified based on selected technology variables. The variables available for this type of analysis were herd breed, barn type, and milking system. Table 4 shows the distribution of technical efficiency according to herd breed owned by farmer. Holstein herds, clearly the most numerous in the sample, were the most efficient followed by Guernsey and Jersey herds, both of which were slightly above average in efficiency. All remaining breeds were below average in technical efficiency.

Table 5, which presents the distribution of barn type and efficiency, shows that there was very little difference in efficiency among the various barn types. The relationship between milking systems and efficiency shown in table 6 suggests that the least efficient system was bucket-and-carry. The pipeline and other parlor systems were slightly above average efficiency while the remaining systems were very close to average.

Another useful comparison of the characteristics of cooperative members and nonmembers relates to their differences in average level of milk output and resource use. Table 7 gives average milk output, number of cows, amount of concentrate feed, labor and feed expense per farm and per cow for cooperative members and nonmembers in 1982, 1983, 1984, and the average of the 3 years. The results of the test for the difference between the average for members compared to that for nonmembers are also given in table 7. In most cases the tests show no significant difference between the averages for cooperative members and nonmembers. Nevertheless, for this particular sample, nonmembers had 10 more cows per farm. They used more concentrate feed and forage but less labor per cow than members. Two characteristics that were significantly different were milk per cow, which is 164.91 hundredweight for nonmembers and 157.08 hundredweight for members; the percentage of Holstein herds was 90.59 and 82.88 percent for nonmembers and members, respectively.

Table 3—Distribution of technical efficiency and milk per cow by cooperative, 1982-84

Cooperative[1]	Technical efficiency	Milk per cow
		cwt/yr
Cooperative 4	0.9465	149.00
Cooperative 5	0.9483	155.70
Cooperative 8	0.9492	149.42
Cooperative 3	0.9865	158.81
Cooperative 10	0.9879	154.99
Cooperative 2	0.9974	154.43
Cooperative 1	0.9985	157.75
Cooperative 11	1.0068	168.24
Cooperative 7	1.0291	156.04
Cooperative 6	1.0539	158.33
Cooperative 9	1.1799	186.74

[1]Cooperative identification numbers do not reflect an alphabetical ordering by name of cooperatives nor are they related to the size of membership.

Table 4—Average efficiency for seven different herd breeds

Herd breed	Number of farms	Efficiency	Milk per cow
			cwt/yr
2/3 Holstein + others	15	0.9544	146.96
Ayrshire	9	0.9969	137.84
Jersey	28	1.0137	134.72
Guernsey	5	1.0206	139.90
Others	38	1.0273	147.78
Holstein	323	1.1219	163.45

Table 5—Average efficiency for three different barn types

Barn type	Number of farms	Efficiency	Milk per cow
			cwt/yr
Freestall	114	0.9959	162.13
Stanchion	235	1.0032	157.36
Others	69	1.0108	157.44

Table 6—Average efficiency for six different milking systems

Milk System	Number of farms	Efficiency	Milk per cow
			cwt/yr
Bucket and carry	17	0.9470	135.88
Dumping station	82	0.9934	153.70
Others	26	0.9953	149.59
Herringbone parlor	99	0.9972	162.78
Pipeline	166	1.0127	161.47
Other parlor	28	1.0271	164.43

Table 7—Average milk output and inputs used for dairy cooperative members and nonmembers

Item	Year	Members	Nonmember	Test of difference
Milk output	1982	10,612.34	12,659.21	–
(cwt)	1983	11,078.39	13,523.90	–
	1984	10,725.27	13,726.74	–
Cows	1982	66.89	76.45	–
(average no.)	1983	68.56	78.22	–
	1984	67.81	80.71	–
Concentrate feed	1982	195.48	249.33	–
(tons)	1983	200.70	256.69	–
	1984	185.29	252.44	*
Labor	1982	2.09	2.27	–
(Man equivalent	1983	2.10	2.28	–
	1984	2.09	2.28	–
Forage	1982	239.00	275.56	–
(tons)	1983	248.78	287.23	–
	1984	243.61	304.16	–
Averages 1982-1984				
Milk output (cwt)		10,805.33	13,303.28	–
Milk per cow (cwt)		157.08	164.91	**
No. of cows		67.75	78.46	–
Concentrate feed(ton)		193.82	252.82	–
Concentrate feed/cow		2.86	3.22	–
Labor (man equivalent)		2.09	2.28	–
Labor/cow		0.013	0.029	–
Forage (ton)		243.80	288.98	–
Forage/cow (ton)		3.60	3.68	–
Holstein %		82.88	90.59	*

* Significant diference between members and nonmembers at a 95 percent level of confidence.

** Significant diference between members and nonmembers at a 99 percent level of confidence.

– Little or no significant difference between members and nonmembers.

Table 8 shows the concentrate feed-milk output response and the forage feed-milk output response, holding all other inputs, except concentrate or forage as the case may be, at the average 1984 levels shown in table 7. The data shown in table 8 are also depicted graphically on figures 1 and 2. They clearly indicate that the milk response curves for concentrate and forage were higher for nonmembers than for members. This is consistent with the higher milk output per farm for nonmembers observed in table 7.

Table 8—Concentrate feed-milk output response and forage feed-milk output response relationships for dairy cooperative members and non-members 1984[1]

Concentrate feed	Milk output		Forage feed	Milk output	
	Members	Nonmembers		Members	Nonmembers
tons	*cwt.*		*tons*	*cwt.*	
20	6502.68	7561.19	20	7888.67	9569.59
40	7603.87	8841.64	40	8594.91	10426.31
60	8332.56	9688.94	60	9036.99	10962.59
80	8891.54	10338.92	80	9364.38	11359.74
100	9350.82	10872.96	100	9626.46	11677.66
120	9743.63	11329.72	120	9846.03	11944.02
140	10088.59	11730.83	140	10035.58	12173.96
160	10397.27	12089.76	160	10202.73	12376.72
*180	10677.38	12415.46	180	10352.47	12558.37
200	10934.33	12714.24	200	10488.27	12723.11
220	11172.09	12990.70	220	10612.66	12874.00
+240	11393.66	13248.34	*240	10727.50	13013.32
+260	11601.36	13489.85	260	10834.25	13142.81
280	11797.04	13717.38	280	10934.02	13263.84
300	11982.18	13932.66	+300	11027.74	13377.53
320	12157.99	14137.09	320	11116.13	13484.75
340	12325.49	14331.86	340	11199.81	13586.26
360	12485.53	14517.95	360	11279.27	13682.66
380	12638.83	14696.20	380	11354.97	13774.48
400	12785.99	14867.32	400	11427.24	13862.16
420	12927.57	15031.94	420	11496.42	13946.07
440	13064.02	15190.61	440	11562.76	14026.56
460	13195.75	15343.78	460	11626.52	14103.90
480	13323.11	15491.87	480	11687.89	14178.34
500	13446.44	15635.27	500	11747.06	14250.12
520	13565.99	15774.29	520	11804.19	14319.42
540	13682.04	15909.23	540	11859.43	14386.43
560	13794.81	16040.35	560	11912.90	14451.30
580	13904.50	16167.89	580	11964.72	14514.16
600	14011.30	16292.08	600	12015.00	14575.16

[1]All other inputs are evaluated at the 1984 average of each group as reported in Table 7. The asterisks (*) and pluses (+) indicate the approximate locations of average input for members and nonmembers, respectively.

Figure 1—Milk Output and Concentrate Feed

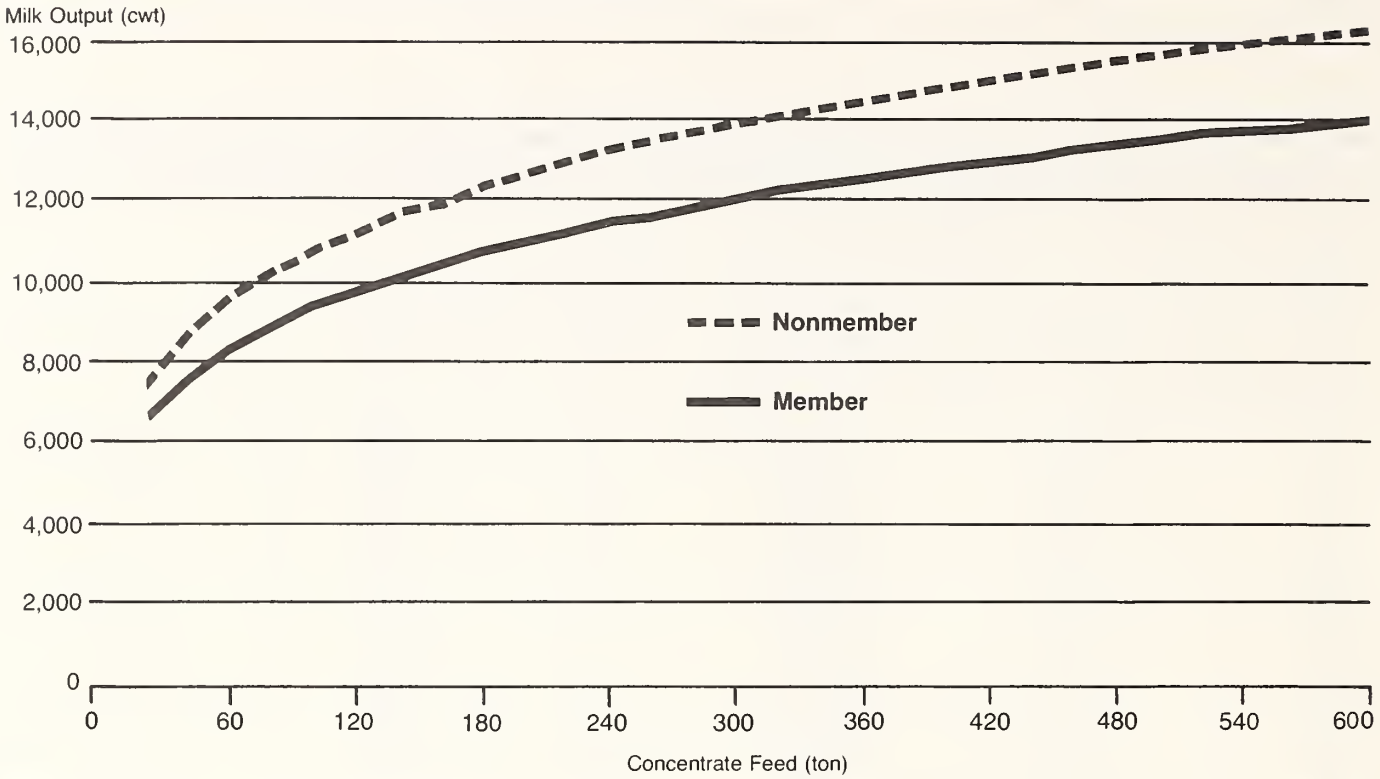
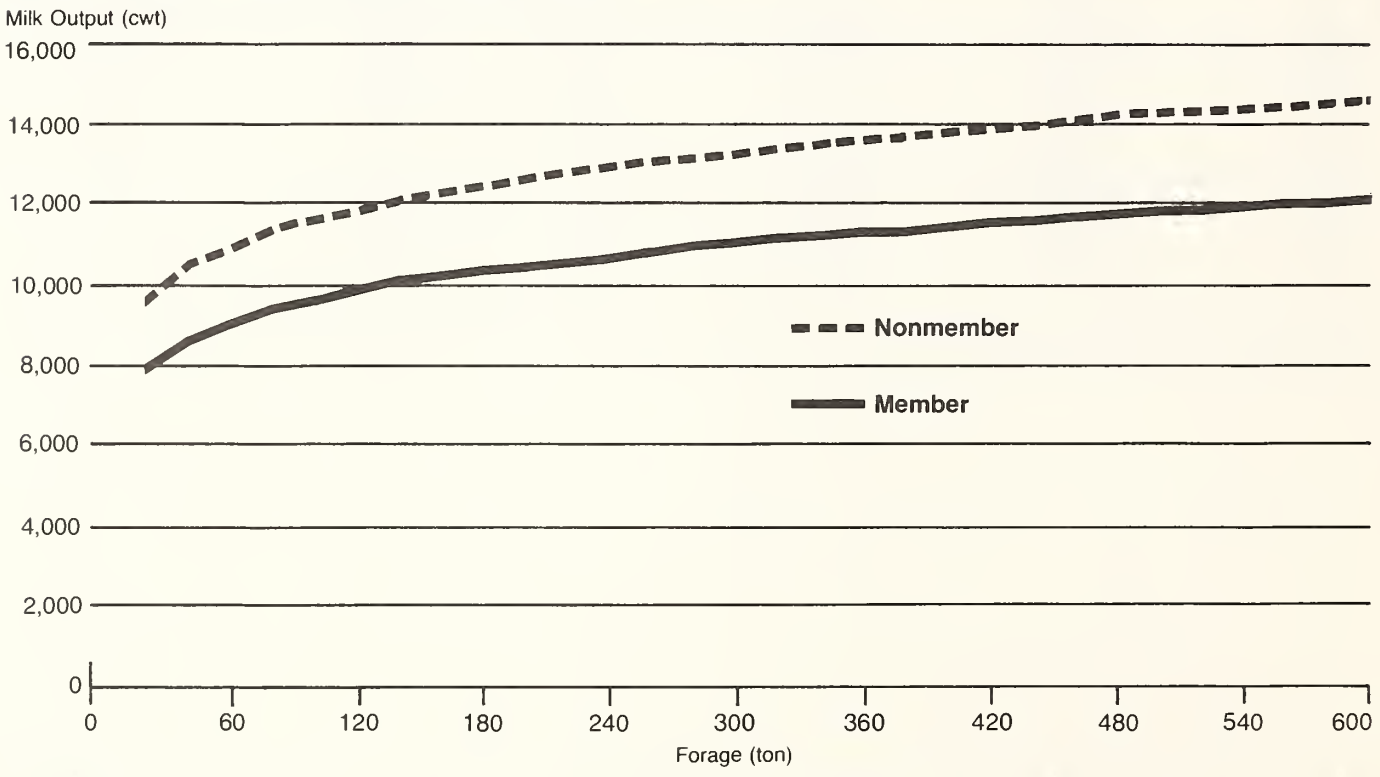


Figure 2—Milk Output and Forage Input



RELATIONSHIP OF SOCIOECONOMIC CHARACTERISTICS TO COOPERATIVE MEMBERSHIP

To identify socioeconomic variables that explain farmers' membership in dairy cooperatives, attempts were made to relate membership to age, years of education, and years of dairy farm experience of the operator; number of cows owned by operator; operator's participation in extension programs; and the level of technical efficiency of the operator generated from the previous section (table 9). All estimated coefficients were not statistically significant, except for the intercept, suggesting that the listed socioeconomic variables did not explain why a farmer was or was not a dairy cooperative member. The variables that had higher test statistics for their estimated coefficients, operator's years of dairy farm experience and number of cows, were negatively related to cooperative membership. The implication was that the more experienced dairy farm operators tended not to join cooperatives, and the larger the size of cow herd, the more unlikely the chance the operator was a cooperative member.

Many alternative hypotheses were tested to determine the significance of the socioeconomic variables in explaining a farmer's membership in a dairy cooperative. However, all of the results showed that technical efficiency was not a significant variable. In other words, a farmer may be a dairy cooperative member regardless of his level of technical efficiency. Acquisition of technical efficiency through a dairy cooperative was not a deciding factor whether or not a farmer would join a cooperative. The decision to be a dairy cooperative member might be motivated by other factors. Indeed, in responding to the socioeconomic survey cited earlier, some farmers wrote in "market security" and "market power" as the major benefits of being a dairy cooperative member.

The average of the socioeconomic variables for cooperative members and nonmembers are given in table 10. Although there were no statistically significant differences between the averages of members and nonmembers, the data show that nonmembers had 10 more cows per farm, and 1 1/2 years more experience in dairy farming.

Table 9—Relationship between cooperative membership and some socioeconomic variables based on a linear regression model

Variable	Estimated coefficient	Level of significance (test statistics)
Intercept	0.9001	** (4.5816)
Age	0.0030	– (1.2797)
Year of education of operator	0.0009	– (0.1369)
Year of dairy farm experience	–0.0033	– (–1.4913)
Number of cows	–0.0005	– (–1.3749)
Technical efficiency	–0.0841	– (–0.5088)
Extension participation	0.0161	– (0.4474)
Multiple correlation	0.0124	
Number of farms	418	

** With a 99 percent level of confidence, the coefficient estimate is significantly different from zero.

– The coefficient estimate is not signifcantly different from zero.

Table 10—Selective descriptive statistics for cooperative members and nonmembers

Average	Members	Nonmembers	Test of difference
Age	46.53	46.58	–
Years of education of operator	12.80	12.81	–
Years of dairy farm experience	23.98	25.42	–
Number of cows	67.75	78.46	–
Technical efficiency	1.0004	1.0106	–
Percent of extention participation	67.81	62.35	–

– The difference between members and nonmembers is not statistically significant.

RELATIONSHIP OF COOPERATIVE MEMBERSHIP TO TECHNICAL EFFICIENCY

The previous analysis clearly indicates that technical efficiency was not a deciding factor whether a farmer was a dairy cooperative member. In this section, the direction of causality is reversed in the analysis. Efforts were made to discover whether technical efficiency was a result of cooperative membership and other socioeconomic characteristics. The result of the analysis are shown in table 11. The socioeconomic characteristics included in the analysis were operator's education, years of dairy farm experience, herd type, the state where the farm is located, milking system, membership on selected cooperatives, and concentrate feed, forage, and labor per cow.

The analysis reveals the following results: (1) bucket-and-carry was the most inefficient milk system, while pipeline and other parlor were the most efficient; (2) farmers in the sample in Maine and Massachusetts were almost 3 percent less efficient than other farmers; (3) farmers that were members of cooperatives 1, 4, 5 and 8 were less efficient than average while members of cooperatives 6 and 7 were more efficient; (4) operators who had more education and had more years of dairy farm experience were more efficient; (5) registered herds were more productive; and (6) given the same number of cows, an increase in the use of concentrate feed and a decrease in the use of forage and labor would yield gains in technical efficiency in milk production.

Table 11—Relationship between technical efficiency and selected variables based on a linear regression model[1]

Variables	Parameter estimate	Standard error	Level of significance
Intercept	–0.7033	0.1310	**
Operator's education	0.0531	0.0234	*
Year of dairy experience	0.0149	0.0072	*
Herd type	0.0448	0.0101	**
State 1 & 4	–0.0285	0.0110	**
Milk system 2	0.1040	0.0252	**
Milk system 3	0.1130	0.0311	**
Milk system 4	0.0688	0.0261	**
Milk system 5 & 6	0.0889	0.0266	**
Cooperative 1, 4, 5, & 8	–0.0346	0.0169	*
Cooperative 6 & 7	0.0439	0.0149	**
Concentrate feed per cow	0.0771	0.0166	**
Forage per cow	–0.0344	0.0160	*
Labor per cow	–0.0685	0.0155	**
R squared	0.1978		

[1]State 1 = Maine
2 = New Hampshire
3 = Vermont
4 = Massachusetts
5 = Connecticut.

Milk System
1 = Bucket and Carry
2 = Pipeline
3 = Other Parlor
4 = Dumping Station
5 = Herringbone Parlor
6 = Other Systems.

* With a 95 percent level of confidence, the coefficient estimate is significantly different from zero.

** With a 99 percent level of confidence, the coefficient estimate is significantly different from zero.

References

This report compared technical efficiency of farmers who were dairy cooperative members with that of nonmembers. Technical efficiency of individual farmers was measured using the average efficiency production function methodology. The average technical efficiencies for members and for nonmembers were then calculated. A statistical comparison of the difference between the two averages showed that dairy cooperative membership for the farmers in this sample had no impact on technical efficiency in milk production.

An effort to explain dairy cooperative membership led to the conclusion that age, years of education of the operator, years of dairy farm experience, number of cows, technical efficiency, and extension participation were not significant factors in explaining whether a farmer was a cooperative member. On the other hand, differences in technical efficiency could be partially explained by operator's education and years of dairy farm experience, herd type, state where the farm was located, milking system, membership on specific dairy cooperatives, and concentrate feed, forage and labor per cow. Whether a farmer was a dairy cooperative member did not seem to have a significant impact on the technical efficiency of the farmer, at least as far as New England dairy farmers were concerned.

1. Bravo-Ureta, B.E. and T.C. Lee. *Socioeconomic Characteristics of Dairy Cooperative Members in New England*. Department of Agricultural Economics and Rural Sociology, University of Connecticut, Manuscript in Progress.

2. Dunn, J.R., G. Ingalsbe, and J. Armstrong. *Cooperatives and Structure of U.S. Agriculture*, in Structure Issues of American Agriculture. USDA, ESCS, Agricultural Economic Report 438, November 1979.

3. Farrell, M.J. *The Measurement of Production Efficiency*. Journal of the Royal Statistical Society Series A 120(1957):253-281.

4. Forsund, F.R., C.A.K. Lovell, and P. Schmidt. *A Survey of Frontier Production Functions and of Their Relationships to Efficiency Measurement*. Journal of Econometrics 13(1980): 5-25.

5. Hoch, I. *Production Functions and Supply Allocations for California Dairy Farms*, Giannini Foundation Monograph, No. 36, July 1976, p. 11.

6. Lang, M.G., E.M. Babb, R.D. Boynton, and L.F. Schrader. *Performance Dimensions for Cooperatives and Proprietary Firms: Perceptions and Research Priorities*. Purdue University, Station Bulletin No. 281, May 1980.

7. Lee, T.C. and B. Bravo-Ureta. *Nonlinear Estimation of Relative Technical Efficiency With a Composite Error Model*, unpublished manuscript, Department of Agricultural Economics, University of Connecticut, 1985.

8. Stafford, T.H., and J.B. Roof, *Marketing Operations of Dairy Cooperatives*, USDA, ACS Research Report Number 40, July 1984.

9. U.S. Department of Agriculture, Agricultural Cooperative Service. *Farmer Cooperative Statistics 1984*. ACS Service Report Number 15, November 1985.

10. U.S. Department of Agriculture, Statistical Reporting Service. *Milk Production*, various issues.

U.S. Department of Agriculture
Agricultural Cooperative Service
Washington, D.C. 20250

Agricultural Cooperative Service (ACS) provides research, management, and educational assistance to cooperatives to strengthen the economic position of farmers and other rural residents. It works directly with cooperative leaders and Federal and State agencies to improve organization, leadership, and operation of cooperatives and to give guidance to further development.

The agency (1) helps farmers and other rural residents develop cooperatives to obtain supplies and services at lower cost and to get better prices for products they sell; (2) advises rural residents on developing existing resources through cooperative action to enhance rural living; (3) helps cooperatives improve services and operating efficiency; (4) informs members, directors, employees, and the public on how cooperatives work and benefit their members and their communities; and (5) encourages international cooperative programs.

ACS publishes research and educational materials and issues Farmer Cooperatives magazine. All programs and activities are conducted on a nondiscriminatory basis, without regard to race, creed, color, sex, age, handicap, or national origin.